(12) UK Patent Application (19) GB (11) 2 100 076 A

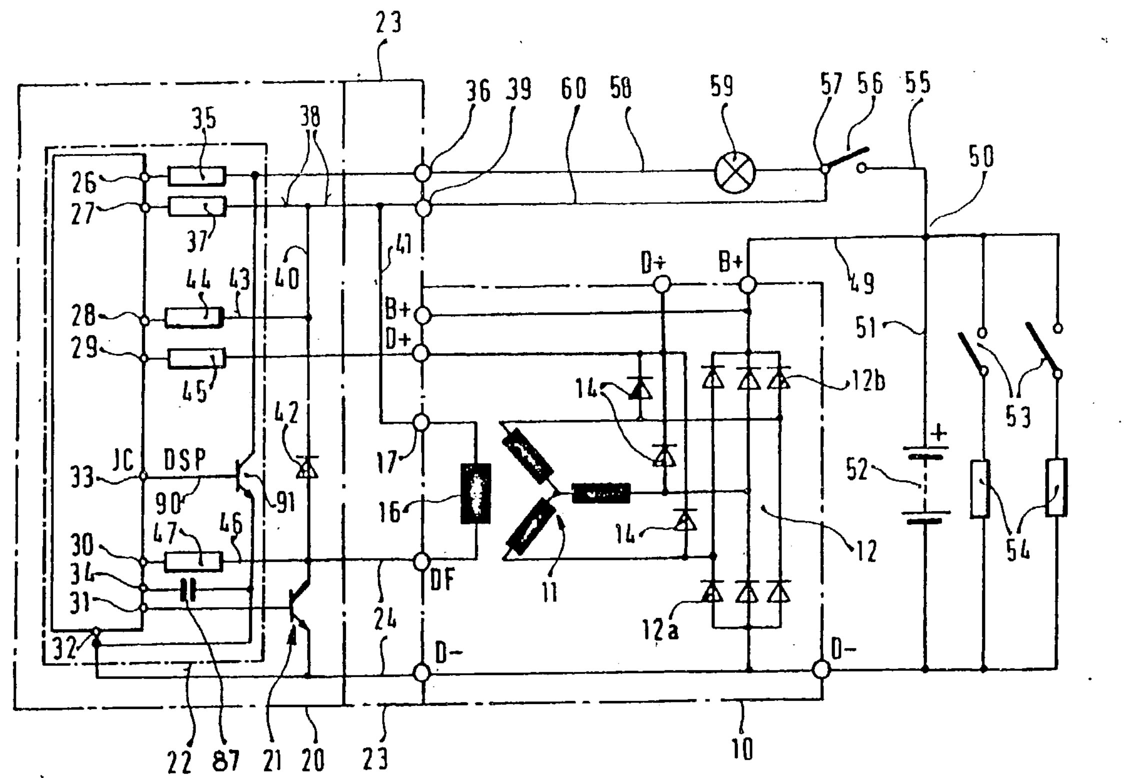
(21) Application No 8209607
(22) Date of filing
1 Apr 1982
(30) Priority data
(31) 3122378
3126055
(32) 5 Jun 1981
2 Jul 1981
(33) Fed Rep of Germany
(DE)
(43) Application published
15 Dec 1982
(51) INT CL³ H03K 17/18
H02J 7/24
(52) Domestic classification
H2H 21R 25G BCB BCD
BGJ
H2K 511 625 634 FH
(56) Documents cited
GB 1499176
GB 1499175
GB 1498875
GB 1457248
DE A1 2809712 =
GB 1603886
WO A 8102956
(58) Field of search
H2H

(71) Applicant
Robert Bosch GmbH
Postfach 50
7000 Stuttgart 1
Federal Republic of
Germany
(72) Inventors
Willi Gansert
Ulrich Munz
Edgar Kuhn
(74) cont. overleaf

(54) Battery charging system

(57) A battery charging system for a vehicle electrical system includes an alternating current generator (10), a voltage regulator (20) and a charging indicator means for indicating faults including faults in the output stage of the regulator. The charging indicator means is provided with a signal generator for detecting the switching state of the power switch (21) of the voltage regulator, a first threshold stage for detecting a minimum value of the generator voltage, and a second threshold stage for detecting a voltage exceeding the desired regulated value by a predetermined value. One input of the first threshold stage is connected to a terminal (D+) of the generator, decoupled from the battery voltage. The input of the second threshold stage is connected to a point (50 or 57) influenced by the battery voltage. Thus the first threshold stage can correctly evaluate the generator voltage, and the second threshold stage can correctly evaluate the state of charge of the battery. The outputs of the second threshold value stage are fed to a logic circuit (Fig. 2) which controls an indicator means (59).

Fig. 1



GB 2 100 076 A

2100076

1/4

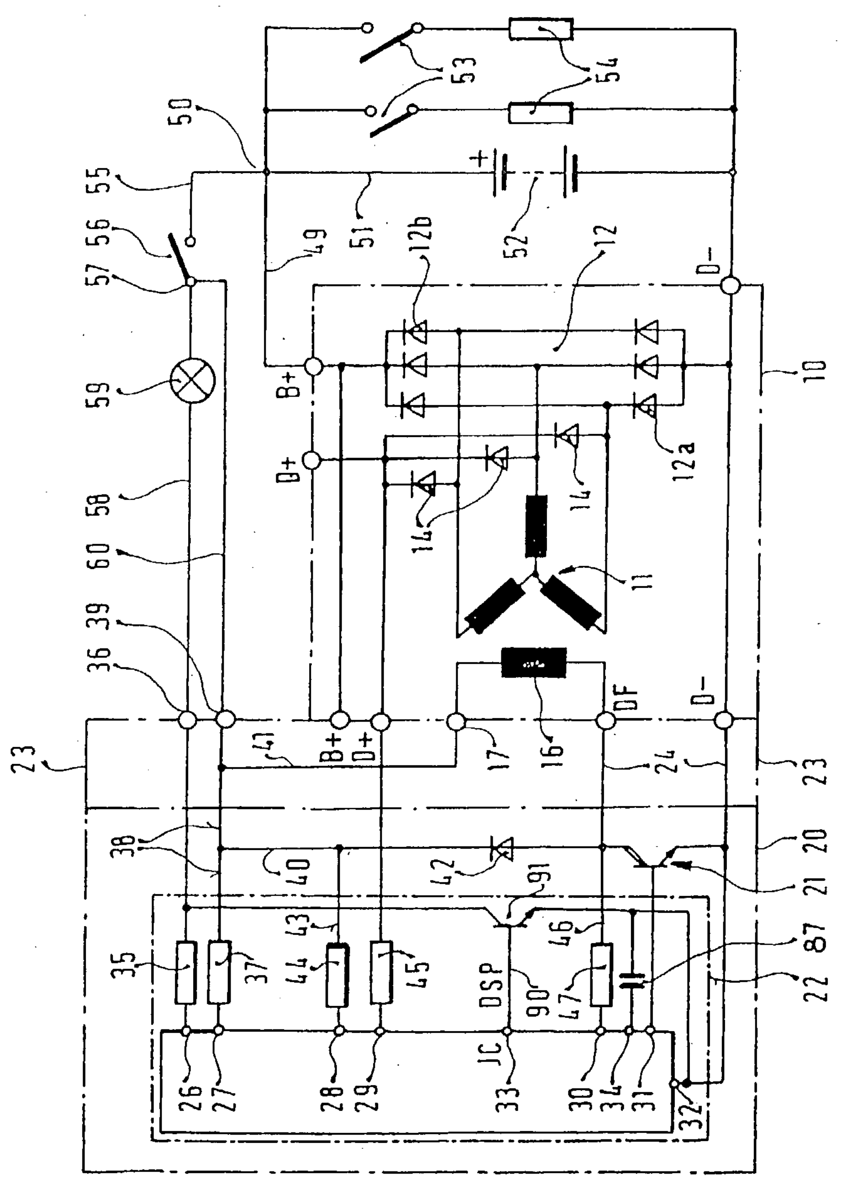


Fig. 1

2/4

Fig. 2

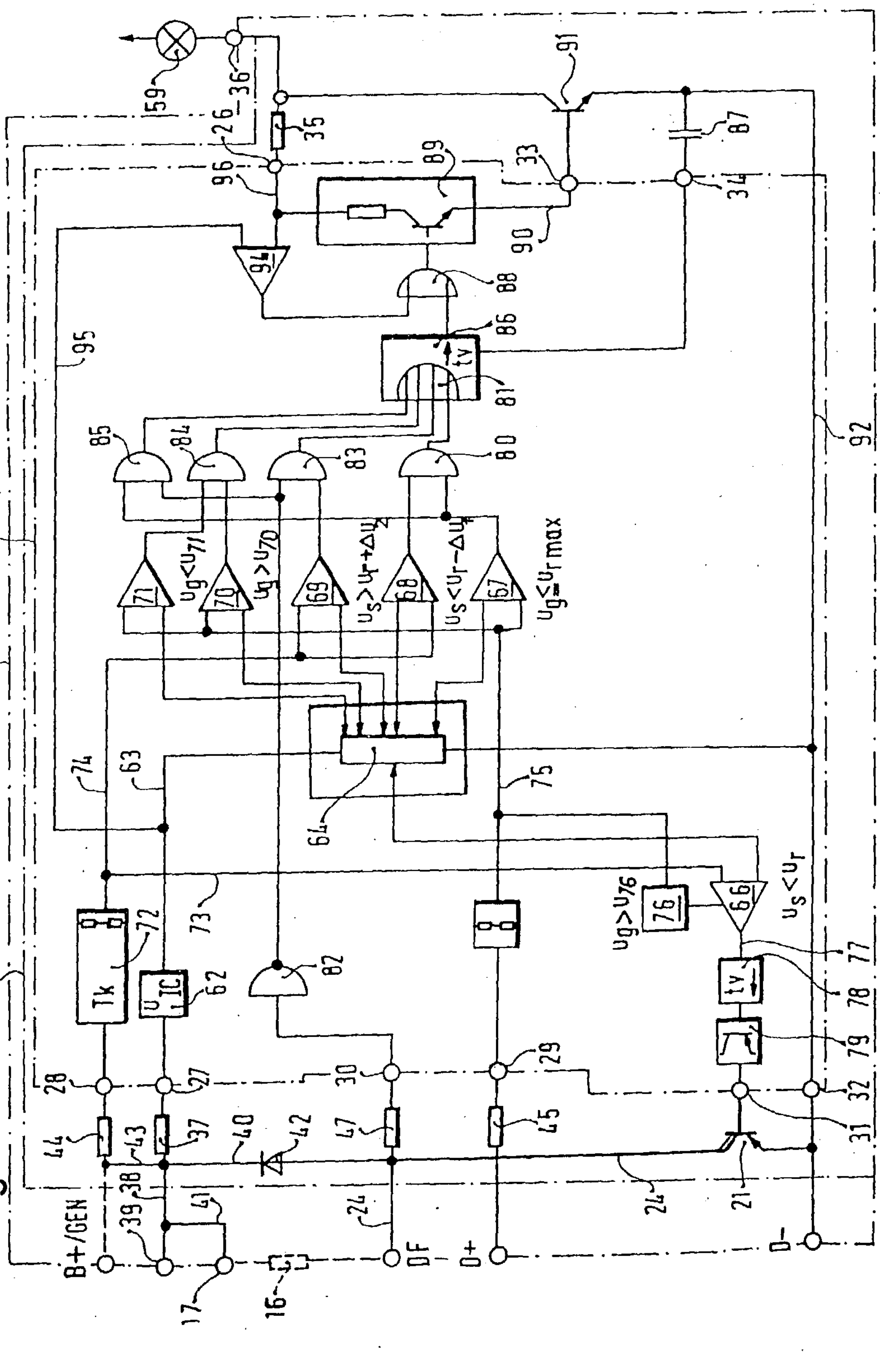

B+/GEN
DF
D+
D−
Tk
$u_g < u_{71}$
$u_g > u_{70}$
$u_s > u_r + \Delta u_2$
$u_s < u_r - \Delta u_1$
$u_g \leq u_{r\,max}$
$u_g > u_{76}$
$u_s < u_r$
tv

Fig. 3a

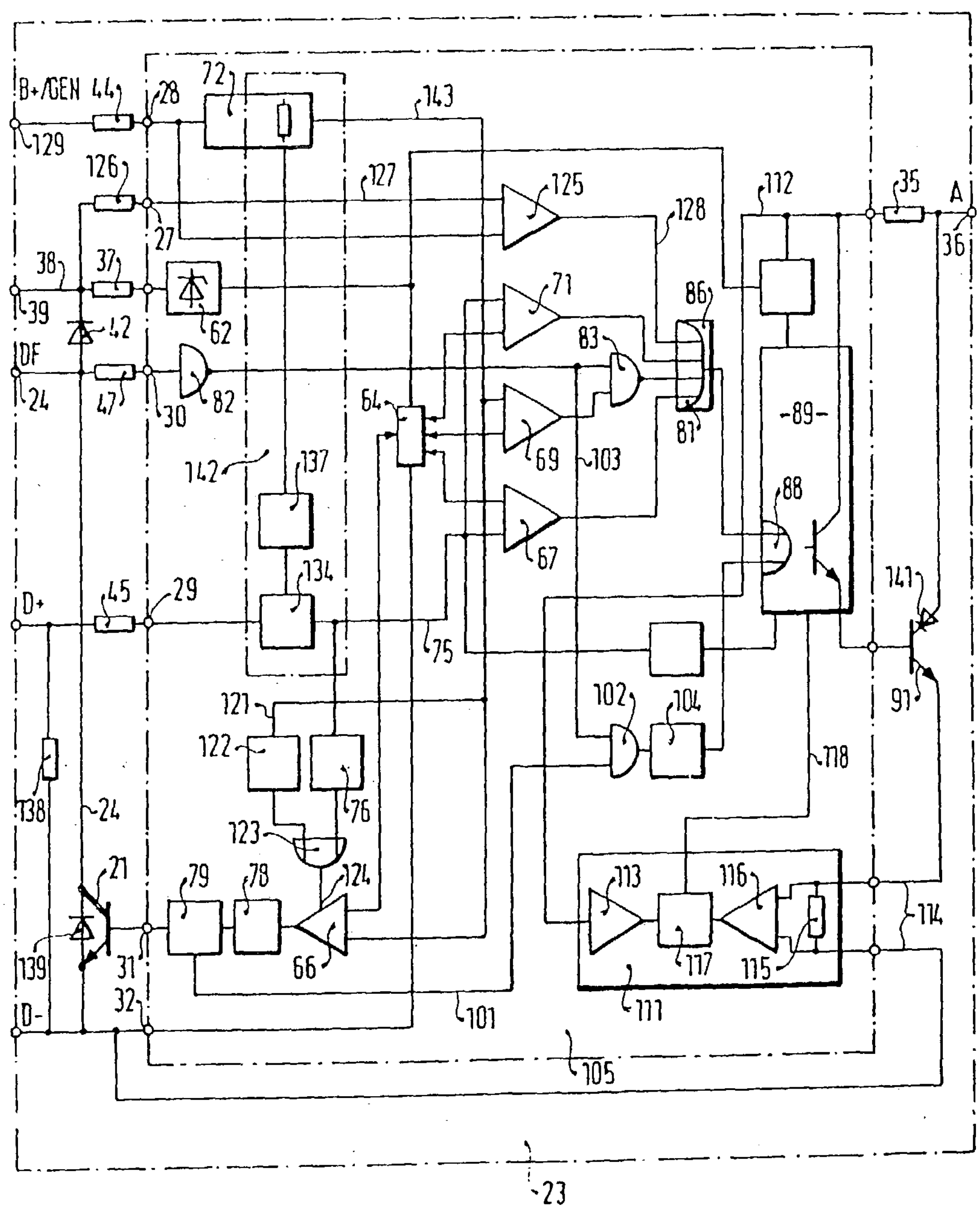


Fig. 3b

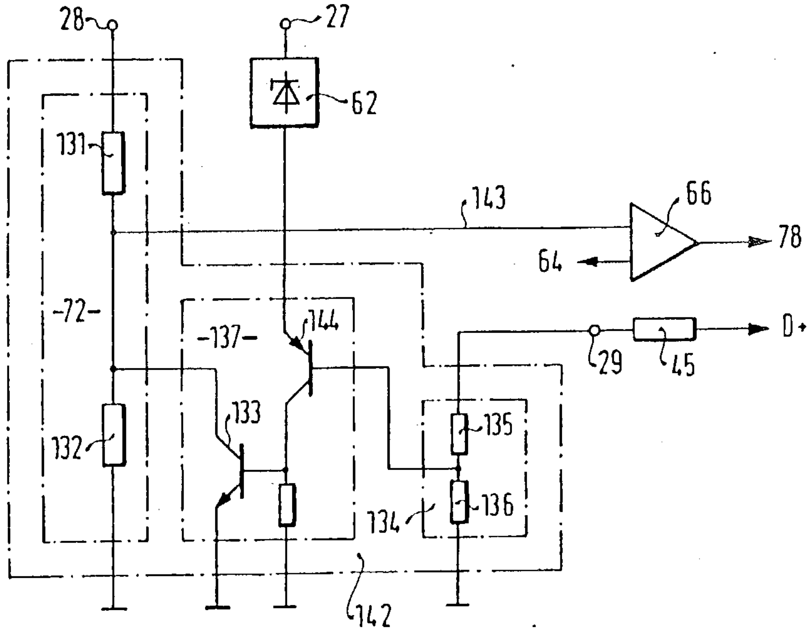
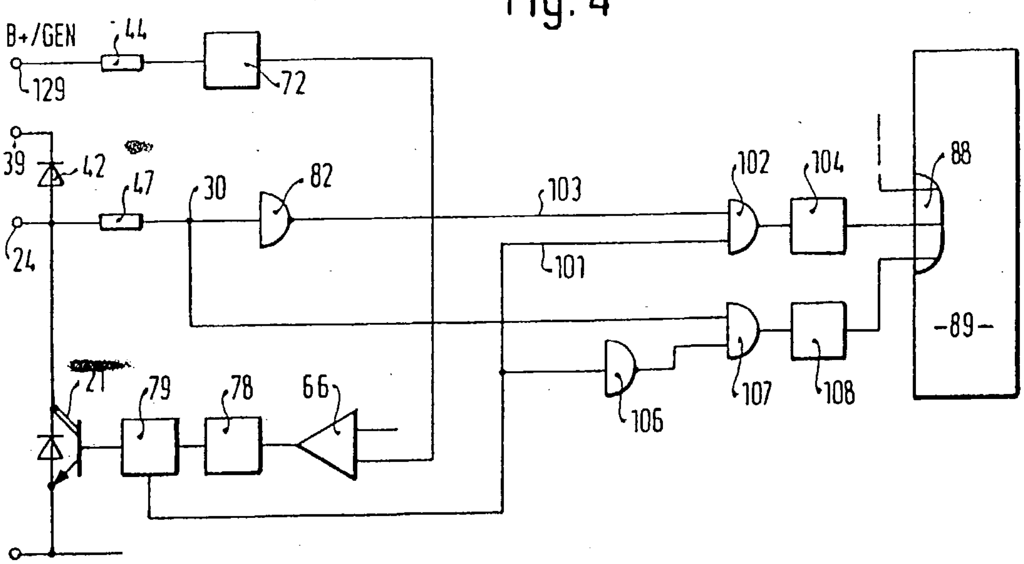

28
27
62
131
143
66
78
64
-72-
-137-
144
29
45
D+
133
135
132
134
136
142

Fig. 4


B+/GEN
44
72
129
39
42
47
30
82
24
103
102
104
88
101
89
21
79
78
66
106
107
108

SPECIFICATION

Battery charging system

The invention relates to battery charging systems.

A battery charging system having a voltage regulator is known from German patent specification (Offenlegungsschrift) No. 28 09 712.3, in which a charging indicator (pilot lamp) indicates stoppage of the generator or fracture of the V-belt by way of a first threshold value stage and, by way of another threshold value stage, gives an indication when a power switch or output stage of the voltage regulator is conductive when the predetermined maximum value of the generator output voltage is exceeded. Moreover, a further threshold value stage is provided through which an indication is given when the power switch of the regulator remains open when the generator output voltage drops below a desired regulated value. In accordance with their function, the signal inputs of the threshold value stages are connected to a terminal in the generator to which the cathodes of field current diodes, and that terminal of the ignition switch which is remote from the battery, are connected. This arrangement cannot detect some faults which can occur in that part of the battery charging system which lies outside the generator. In particular, it is impossible to check the regulator output stage, serving as a power switch in series with the generator field winding, for a short-circuit or interruption.

The present invention provides a battery charging system comprising an alternating current generator for feeding an electric battery and including an excitation system and a rectifier system, a semiconductor voltage regulator for maintaining the generator voltage constant and having a power switch connected in series with the excitation winding, and a charging indicator means which has a signal generator means for indicating the switching state of the power switch, a first threshold stage adapted to respond to a minimum value of the generator voltage, one signal input of the first threshold value stage being connected for this purpose to a fault detection terminal which is decoupled from the battery voltage and which is fed by detection diodes in the excitation system of the generator, and a second threshold value stage adapted to respond to a voltage which is produced by the generator and which exceeds the desired regulated value by a predetermined value, one signal input of the second threshold stage being connected for this purpose to a sensing terminal influenced by the battery voltage, the output signals of which second threshold value stage are fed to a logic combination circuit which controls an indicator means.

This has the advantage that the first threshold value stage instantaneously, and also otherwise unaffected by the state of charge of the battery, detects the generator voltage or the conditions in the excitation system of the generator, such as the switching state of the voltage regulator. The other threshold value stage and, if required, further threshold value stages, correctly detect the state of charge of the battery or the potential of a sensing connection dependent upon the voltage of the battery, thus resulting in the possibility of providing a number of further monitoring functions.

Preferably, the excitation winding of the generator is fed with voltage by a battery even during operation, and the fault detection terminal is fed with voltage solely by the detection diodes which are connected as a half-wave bridge rectifier set. Thereby the desired monitoring functions of the charging indicator can be obtained at a relatively low expense.

It is particularly advantageous if the threshold value of the first threshold value stage, provided for detecting a minimum value of the generator output, is adapted to respond at a minimum value of the generator voltage which lies above the voltage value produced solely by the remanence of the excitation system at the maximum speed of the generator. The first threshold value stage then clearly signals whether the running generator is energized or not. When dimensioning the first threshold value stage in this manner, undesirable indication of faults when the generator is energized can be suppressed if the first threshold value stage is combined with further switching means. Towards this end, the output signals of the first threshold valve stage and of the signal generator means, serving to detect the switching state of the power switch, are fed to a logic AND circuit which initiates an indication only when the power switch is conductive and the generator voltage is not higher than the threshold value of the first threshold value stage. This prevents indication of faults when the regulator de-energizes the generator at the end of a charging operation, or when a load is switched off from load operation when the battery is satisfactorily charged. Preferably, the output signals of the first threshold value stage and of a further threshold value stage, which is adapted to respond to a sensed generator voltage lying below the desired regulating value by a predetermined value, are fed to a logic AND circuit which initiates an indication only when the generator voltage is not higher than the threshold value of the first threshold value stage and the sensed voltage is lower than the threshold value of the further threshold value stage. When the generator is de-energized, fault indication is thereby suppressed as soon as, and as long as, the battery voltage or the voltage on the sensing connection dependent

thereon, exceeds a minimum value lying by a predetermined difference below the desired regulating value.

The regulator switches on the excitation current again when a load is switched on and the battery or sensing voltage thereby drops below the desired value or a predetermined minimum value, whereupon the voltage on the fault detection terminal of the generator commences to rise. In order to avoid fault indication during the period in which the generator voltage has not yet reached the threshold value of the first threshold value stage, a time delay circuit can be connected to the outputs of the two said AND circuits, the time delay of which time-delay circuit corresponds to at least the time during which the voltage on the fault detection terminal rises from the minimum possible residual voltage to the maximum possible residual voltage at the minimum operating speed of the generator.. If the generator voltage has still not reached the predetermined threshold value after the expiry of this time delay, interruption in the excitation as a result of damage to the regulator, or interruption of the current path in the generator leading to the fault detection connection exists and leads to fault indication.

The indicator is also activated when that terminal of the excitation winding of the generator which is remote from the positive terminal of the battery or remote from the ignition switch is short-circuited to earth.

A break in the charging line leading from the generator to the battery can be indicated if the fault detection terminal is connected to the signal input of an additional threshold value stage which is arranged to activate the indicator means and whose threshold value lies above that of said second threshold value stage. In order to protect the indicator against over-voltage, a second additional threshold value stage can be provided, such that the fault detection terminal is connected to the signal input of a second additional threshold value stage whose threshold value is higher than that of the first additional threshold value stage, and the output signals of these two additional threshold value stages are fed to AND circuit which suppresses indication when the second additional threshold value stage has responded. Advantageously, in order to avoid a rise in the generator voltage to an admissibly high value in this eventuality, means for emergency regulation of the generator can be provided.

A development of the charging system is proposed in order to indicate interruptions in the leads in the vehicle electrical system. An interruption in the lead between the ignition switch and the excitation winding of the generator can be indicated. An interruption in the charging lead can also be indicated, the regulator in this case continuing to regulate to the normal voltage level.

In the event of a short circuit of the pilot lamp as a result of, for example, reversing the lamp terminals during assembly, the current flowing through the leads to the indicator lamp is automatically limited.

The invention includes a battery charging system which includes a generator and a voltage regulator and in which, in operation a normal signal is taken from a pre-amplifier circuit connected to the input of a voltage regulator output stage and is fed to an AND circuit; the output signal of signal generator means responsive to generator output voltage is fed to said AND circuit; the output signal of said AND circuit is fed to an OR circuit by way of a switching delay stage; the output signal of a timing circuit is also fed to said OR circuit; one input of the timing circuit is connected to the output of the signal generator means, by way of further components if necessary, and the output signal of the OR circuit is fed to indicator means, by way of an indicator output stage, if required.

Since the voltage regulator controls the excitation output such that the generator output voltage remains constant, an interruption in the charging lead cannot be directly detected. However, the charging indicator means in accordance with the invention then monitors the potential on the control (ignition) switch. This potential drops slowly when the charging lead is interrupted, since the battery is not being charged. The pilot lamp is switched on if the potential on the control switch has then dropped by a predetermined value.

If the sensing lead measuring the generator output voltage is interrupted, the charging voltage would rise as a result of continuous excitation. However, the output stage of the regulator is blocked in such a case, and thus the generator is necessarily deenergized.

By virtue of a readjustment circuit, a fault is not indicated when the system is intact when the battery is fully charged and is connected to the system and a load having a high power consumption is switched off. The fault indication would otherwise be given, since the generator, which is then highly energized, is completely deenergised over a long period of time and thus an interruption of the excitation is simulated.

Moreover, a NAND circuit and a capacitor can be saved by virtue of the readjustment circuit.

The main current diodes of the rectifier system have differing leakage currents, particularly as a result of differing cooling conditions. This could lead to faulty indication owing to the high input resistance of the indicator circuit. This can be prevented by incorporating a resistor at an input of the indicator circuit.

Damage to the voltage regulator and the indicator circuit can occur when switching off inductive loads by way of the control (ignition)

switch. Therefore, advantageously, additional diodes are provided in the output stage transistors of these components.

The invention is further described, by way of example, with reference to the accompanying drawings, in which:–

Figure 1 is a simplified circuit diagram of an entire battery charging system;

Figure 2 is an operational circuit diagram of the regulator and of the charging indicator of the battery charging system;

Figures 3a and 3b show a variant of the circuit of Fig. 2, Fig. 3b being a detail of Fig. 3a; and

Figure 4 is a block circuit diagram of a development of the variant.

The battery charging system shown in Fig. 1 comprises a three-phase generator 10 having a three-phase winding 11 to whose output is connected a main current three-phase full-wave rectifier 12 comprising negative diodes 12a and positive diodes 12b. The rectifier 12 has two negative terminals D-serving as the earth connection of the generator, and two positive terminals B + . A set of excitation diodes 14, serving also as fault detection diodes, is connected to the output of the three-phase winding 11 in the manner of a three-phase half-wave bridge rectifier, the cathodes of which excitation diodes are connected to two further positive terminals D + of the generator. The positive terminals D + are hereinafter designated "fault detection terminals" of the generator. Furthermore, the generator has an excitation winding 16 which is connected to a terminal DF and a terminal 17 of the generator.

A voltage regulator 20 is connected to the generator 10 and comprises a semiconductor power switch 21 and a control part 22 and, together with a brush holder 23, forms a structural unit. The power switch 21 is located in a lead 24 between a terminal DF and a terminal D – of the brush holder 23. These two terminals of the brush holder 23 are connected to the corresponding terminals DF and D – of the generator 10. The control part 22 is partially in the form of an integrated circuit IC and has nine terminals 26 to 34 on the integrated circuit, the terminal 26 being connected to a terminal 36 of the brush holder 23 by way of a resistor 35, and the terminal 27 being connected to a terminal 39 of the brush holder 23 by way of a resistor 37 and a lead 38. Leads 40 and 41 branch from the lead 38, one lead 40 being connected by way of a freewheeling diode 42 to the colector of the power switch 21 and to the terminal DF, and the other lead 41 being connected to the terminal 17 of the brush holder 23, which is connected to the generator terminal 17. Thus the diode 42 is connected with severe polarity in parallel with the excitation winding 16.

The terminal 28 of the integrated circuit IC of the control part 22 is connected to the lead 40, and thereby to the lead 38, by way of a lead 43 which incorporates a resistor 44, and the terminal 29 is connected by way of a resistor 45 to the terminal D + of the brush holder 23 which is connected to the terminal D + of the generator 10. The terminal 30 is connected to the terminal DF by a lead 46 by way of a resistor 47 to the collector terminal of the power switch 21, and the terminal 31 is connected to the control input of the power switch 21. The control part 22 is connected by way of the terminal 32 to the emitter of the power switch 21 and the terminal D – . Discrete components of a charging indicator are connected to the terminals 33 and 34 of the integrated circuit IC of the control part 22 and will be further described below.

A connection point 50 of the vehicle electrical system is connected to one terminal B + of the generator 10 by way of a lead 49 and, by way of a lead 51, to the positive terminal of a battery 52 whose other terminals is connected to earth by way of the terminal D – of the generator. The electrical loads 54 of the vehicle are connected to the connection point 50 by way of switches 53. Furthermore, a lead 55 is connected between the connection point 50 and an ignition switch 56 whose terminal 57 remote from the battery is connected to the terminals 36 by way of a lead 58 incorporating a pilot lamp 59, and to the terminal 39 of the regulator 20 or brush holder 23 by way of a second lead 60.

Referring to Fig. 2, the terminal 27 in the control part 22 is connected to a constant voltage source 62 which is connected by way of a lead 63 to a voltage divider 64 which then leads to the terminal 32. The voltage divider 64 supplies the reference voltages for first inputs of six threshold value stages 66 to 71 whose function will be further described later. The terminal 28 of the integrated circuit IC of the control part is connected to a circuit element 72 for the purpose of temperature adaptation, the circuit element 72 being connected to the second inputs of the threshold value stages 66, 68 and 69 by way of leads 73 and 74. The second inputs of the threshold value stages 67, 70 and 71 are connected to the terminal 29 of the integrated circuit IC of the control part 22 by way of a lead 75 to which a circuit element 76 for emergency regulation of the generator is also connected. The output of the circuit element 76 is connected to the threshold value stage 66 whose output is connected by a lead 77 to the terminal 31 of the control part by way of a timing circuit 78 and an amplifier circuit 79.

The output signals of the threshold value stages 67 and 68 are fed to a logic AND element 80 whose output is connected to a logic OR element 81. An inverter 82 is connected via the terminal 30 and the resistor 47

to the collector of the power switch 21 so that the output of the inverter 82 indicates the switching state of the power switch 21. The output signal of the threshold value stage 69 and the output signal of the inverter 82 are fed to a logic AND element 83 whose output is also connected to the logic OR element 81. The outputs of two further logic AND elements 84 and 85 are connected to the input of the logic OR element 81, the logic AND element 84 being triggered at its input by the output signals of the threshold value stages 70 and 71, and the other logic AND element 85 being triggered at its two inputs by the output signals of the threshold value stage 67 and of the inverter 82.

The logic OR element 81 is combined with a timing circuit 86 having a capacitor 87. The capacitor 87 is a discrete component and is connected to the remainder of the electronic timing circuit 86 by way of the terminal 34. The timing circuit 86 triggers a further logic OR element 88 whose output controls a circuit element 89 in a control lead 90 of an electronic switch 91 to whose emitter the capacitor 87 is connected. The electronic switch 91 is located in a lead 92 which interconnects the terminals 26 and 32 of the integrated circuit IC of the control part 22 by way of the resistor 35. The control lead 90 is connected to the base or control electrode of the switch 91 by way of the terminal 33 of the integrated circuit IC of the control part 22. A second signal input of the logic OR element 88 is connected to the output of a comparator 94 whose first input is connected to the lead 63 by way of a lead 95, and whose second input is connected to the terminal 26 of the integrated circuit IC of the control part 22 by way of a lead 96. The logic elements 80 to 85 are hereinafter designated "gates".

A positive output signal activating the power switch 21 is supplied by the threshold value stage 66 as soon as, and for as long as, the voltage u_s at the sensing input of the regulator 20 is below the regulating voltage u_r. In the embodiment of Fig. 2, the sensing input is that terminal 39 of the regulator 20 and of the brush holder 23 which is connected to the ignition switch terminal 57 remote from the battery. Alternatively, however, one of the terminals B+ of the generator 10 can serve as the sensing input, as is indicated in Fig. 2 by a dotted line.

A positive output signal "H" required for activating the switch 91 and for switching on the pilot lamp 59 is supplied by the threshold value stage 67 as soon as, and for as long as, the voltage u_g on the fault detection terminal D+, that is to say, the voltage actually generated by the generator, does not exceed the voltage u_{rmax} which results solely by reason of the remanence of the excitation system at the maximum possible rotational speed of the generator.

A positive output signal "H" required for activating the switch 91 is supplied by the threshold value stage 68 as soon as, and for as long as, the sensed voltage u_s on the sensing input 27 or on the terminal B+ of the regulator is below the value of the regulating voltage u_r by a predetermined difference Δu_1.

On the other hand, the threshold value stage 69 responds to indicate a fault when the sensed voltage u_s exceeds the regulating voltage u_r by a predetermined value Δu_2.

The threshold value stage 70, whose input is connected to the fault detection terminal D+, supplies a positive output signal "H" to indicate a fault when the generator voltage u_g exceeds a limiting voltage u_{70} of, for example, 17 volts.

The threshold value stage 71 provided for protecting the pilot lamp 59 against overload supplies a positive output signal "H" for as long as the generator voltage u_g prevailing at the fault detection terminal D+ lies below an upper limiting value u_{71} of, for example, 24 volts. The switching element 76 responds to block the power switch 21 in the regulator 20 when the generator voltage u_g exceeds a limiting value u_{76} of, for example, 18 volts.

The comparator 94 supplies a switching-on signal "H" for the pilot lamp 59 when the voltage supply u_s on the terminal 27 of the regulator is interrupted. This is the case when the current path, leading to excitation winding 16 of the generator, between the ignition switch 56 and the terminal 39 of the regulator is interrupted. In this case, the comparator 94 switches over such that it draws its power supply by way of the pilot lamp 59 and forms therefrom the positive switching-on signal for the pilot lamp 59.

The timing circuit 86 is designed such that its switching-on delay time corresponds at least to the period of time during which, upon starting the generator, the generator voltage increases from the minimum possible residual voltage of approximately 0 volts to the maximum possible residual voltage at the minimum operating speed.

With respect to the charging of the battery and maintaining the battery voltage constant, the described system operates like a known system in which the generator is excited separately, so that this will not be further discussed.

The mode of operation of the charging indicator and the emergency regulation of the system will be described hereinafter with reference to the possible cases of operation listed below:

1. Normal operation
1.1 Starting (generator inoperative)
1.2 Generator starting and system intact
1.3 Overloading of generator and system intact

1.4 Switching off loads with battery, and system intact
2. Fault operation
2.1 Fracture of V-belt
2.2 Interruption of excitation as a result of damage to the regulator
2.3 Interruption of excitation in the generator
2.4 Full excitation as a result of a short-circuit in the regulator
2.5 Interruption of the battery charging lead
2.6 Interruption of the excitation lead between the ignition switch and the regulator.

1.1 Starting (generator inoperative):
When the generator is stationary, the battery voltage u_s is below the regulating voltage u_r. The sensing path, which leads by way of the ignition switch 56 and the lead 60 to the input of the regulator and then to the threshold value stage 66 by way of the circuit element 72, is at a lower voltage than that of its reference branch at the voltage divider 64. The power switch 21 of the regulator is activated, whereby the DF potential falls to the signal "L". When the generator is stationary, the voltage u_g at the fault detection output D + is zero. The threshold value stage 67 therefore applies the signal "H" to one input of the gate 80.

When DF is equal to "L", a signal "H" is also applied to the gates 83 and 85 by way of the inverter 82. The gate 85 thereby opens the gate 88 by way of the timing circuit 86, and the circuit element 89 activates the pilot lamp 59 by way of the switch 91.

1.2 Starting of the generator with intact system:
The power switch 21 of the regulator is switched on and remains switched on until the voltage u_s on the sensing line exceeds the regulating voltage u_r. This can be the case when the rotational speed *n* of the generator is, for example, 1200 r.p.m. The voltage u_g on the fault detection output D + also increases as the rotational speed of the generator increases. When the voltage u_g exceeds the threshold value u_{rmax} of the threshold value stage 67, the threshold value stage 67 switches over its output, and thus one input of each of the gates 80 and 85, to "L". The stoppage indication signal of the gate 85 is thus cancelled, and the indication which may also possibly have been effected, and which is initiated by the threshold value stage 68 when the voltage u_s drops below the threshold value $u_r - \Delta u_1$ of the threshold value stage 68, is likewise cancelled by logic "L" at one input of the gate 80.

1.3 Generator overload with system intact:
In this case, the sensing voltage u_s drops below the desired regulating value u_r. If the sensing voltage u_s drops below the threshold value of the threshold value stage 68, the latter applies the signal "H" to one input of the gate 80. However, when the system is intact and the generator is rotating, the regulator must have been switched on when the sensed voltage u_s dropped below the regulating voltage u_r. The voltage u_g on the fault detection output D + is higher than the maximum possible residual voltage u_{rmax}. Therefore, the threshold value stage 67 applies an "L" signal to the other input of the gate 80. Thus, a fault indication when $u_s < u_r \Delta - u_1$ is supressed when the system is intact and the generator is rotating.

1.4 Switching off loads with battery, and system intact:
In this operating state, voltage transients can occur on the sensing lead 38 and the sensed voltage u_s may exceed the value $u_r + \Delta u_2$. The threshold value stage 69 then responds and applies a "H" signal to one input of the gate 83. Since the operable regulator blocks the power switch 21 when the regulating voltage is exceeded, the potential at DF is "H". The inverter 82 forms the signal "O" therefrom and applies the latter to the second input of the gate 83. Consequently, the signal "L" also appears at the output of the gate 83, and over-voltages on the sensing lead 38 are not indicated when the regulator is switched off.

After the load has been switched off, the sensed voltage u_s on the sensing lead exceeds the desired regulating value u_r, whereby the power switch 21 assumes its non-conductive state and the generator is de-energized. The output signal of the inverter 82 then jumps to the signal "L", so that a fault indication cannot be initiated by way of the threshold value stage 69.

When loads connected to the battery are switched off, it is possible that the load on the vehicle electrical system will be such that the required current is supplied by the generator. The previously satisfactorily charged battery will then not be discharged. If the load is then switched off, the current, decaying with the time constant of the generator, continues to flow into the battery. The battery voltage and the sensed voltage u_s are thereby increased. The battery voltage decays with the time constant of the battery. However, since the time constant of the battery can be greater than the time constant of the generator, the generator is de-energized. The voltage u_g at the fault detection output D + thereby drops to the residual voltage with the time constant of the generator. This residual voltage is lower than the maximum possible residual voltage. The following operations are thereby initiated.

a) The threshold value switch 67 applies the signal "H" to one input of the gate 80. However, since the sensed voltage u_s on the sensing lead is greater than the voltage u_r of the desired regulating value, the threshold

value stage 68 applies the signal "L" to the other input of the gate 80, so that fault indication does not occur.

b) If the sensed voltage u_s has exceeded the switching threshold $u_r + u_2$ of the threshold value stage 69, the latter applies the "H" signal to one input of the gate 83. Since the power switch 21 is non-conductive, the inverter 82 applies the signal "L" to the other input of the gate 83, so that fault indication also does not occur by way of this path.

c) The threshold value stage 67 applies the signal "H" to one input of the gate 85, whereby the other input of this gate receives the signal "O" from the inverter 82. Thus, the pilot lamp 59 is also not switched on by way of the gate 85.

If the sensed voltage u_s on the sensing lead drops below the desired regulating value u_r during the period of time in which the generator is still de-energized, the regulator again activates the power switch 21 and the following operation is initiated:

The voltage u_g at the fault detection output D+ continues to rise after the regulator has been switched on, although it is still smaller than the response threshold of the threshold value stage 67 for a certain period of time. The "1" signal remains at the output of the threshold value stage 67 during this period of time. When the sensed voltage u_s drops below the threshold value $u_r - \Delta u_1$ of the threshold value stage 68, the signal "H" is also applied to the gate 80 by way of the threshold value stage 68, so that the signal "H" also appears at the output of the gate 80 and the timing circuit 86 is activated.

Moreover, the signal "H" is also present at the two inputs of the gate 85, since the voltage u_g is lower than the threshold value of the threshold value stage 67 and has activated the power switch 21. Thus, the timing circuit 86 is also activated by way of the gate 85. According to the value of the sensed voltage u_s, the timing circuit 86 remains activated either by the two gates 80 and 85 or solely by the gate 85 until the voltage on the fault detection terminal D+ has again exceeded the maximum possible residual voltage, whereby the threshold value stage 67 changes over to the signal "L" and blocks the two gates 80 and 85. As a result of the dimensioning, already described above, of the timing circuit 86, the pilot lamp 59 is not switched on for the duration of this operation.

2.1 Fracture of V-belt:

In this case, the indicator operates in the same manner as when the generator is not running, the pilot lamp 59 in this case lighting up to indicate a fault.

2.2 Interruption of excitation as a result of damage to the regulator:

If the power switch 21 in the regulator is incorrectly blocked, the voltage u_g on the fault detection terminal D+ drops to the residual voltage, whereby the threshold value stage 67 applies the signal "H" to one input of the gate 80. Furthermore, when the power switch 21 is incorrectly blocked, the sensed voltage u_s on the sensing lead also drops. When this voltage drops below the threshold value $ur - \Delta u_1$ the threshold value stage 68 also applies a positive signal to the associated input of the gate 80, whereby the pilot lamp 59 is activated and a fault is indicated.

2.3 Interruption of excitation in the generator:

The residual voltage appears at the fault detection terminal D+ as a result of interruption of the excitation current circuit in the generator in, for example, the region of the brush holder 23. The threshold value stage 67 thereby activates the gate 85 to indicate a fault. The power switch 21 is switched on, since the sensed voltage u_s drops below the regulating voltage u_r as a result of the interruption of excitation, whereby the potential at DF drops to "L". The inverter 82 thereby also applies the signal "H" to the associated input of the gate 85, whereby the pilot lamp 59 is activated by way of the timing circuit 86. Interruption of excitation in the generator is evaluated as a stoppage of the generator.

2.4 Full excitation as a result of a short-circuit in the regulator:

A short-circuit of DF to earth might incorrectly occur in the generator. The signal "H" thereby appears at the output of the inverter 82 and, owing to the sensed voltage u_s at the same time rising above the value $u_r + \Delta u_2$, the threshold value stage 69 also positively activates the gate 83 to indicate a fault. A positive signal thus also appears at the output of the gate 83 and switches on the pilot lamp 59.

2.5 Interruption of the battery charging lead:

When an interruption in the battery charging lead between the terminals B+ of the generator and the positive terminal of the battery 52 occurs, it is possible that the battery will no longer be charged. Its voltage drops below the regulating voltage u_r, this being signalled to the regulator by way of the ignition switch 56 and the sensing lead 60. The power switch 21 in the regulator is activated by the drop in the battery voltage. The voltage on the terminal B+ of the generator and at the fault detection terminal D+ rises, and, in dependence upon the rotational speed, voltages in excess of 150 volts might occur if additional measures are not taken.

The voltage rise at the fault detection terminal D+ is detected by the threshold value stage 70 and is applied to the gate 84 as a "1" signal. The same signal is at the same time also applied to the gate 84 by way of th

threshold value stage 71, so that the indicator means is activated.

If the voltage u_g at D + continues to rise and reaches the threshold value of the threshold value stage 71, the latter converts the output signal "H" to the signal "L", whereby the pilot lamp 59 is extinguished. This measure serves to protect the pilot lamp 59 against over-voltage.

In addition to this fault indication, the arrangement in accordance with the invention also provides for emergency regulation of the generator. If the voltage u_g at the fault detection terminal D + reaches the threshold of, for example, 18 volts, of the circuit element 76, the circuit element 76 intervenes in the regulation operation from the sensing lead and thereby limits the voltage on the terminal B + of the generator and on the fault detection terminal D + to a predetermined value.

2.6, Interruption of the excitation lead between the ignition switch and the regulator:

If the lead 60 between the regulator and the ignition switch 56 is interrupted, the excitation current for the generator and the power supply for the indicator of the system fail. As far as the system is concerned, this is equivalent to interruption of excitation in the generator. However, owing to the failure of the power supply, the indicator means cannot evaluate this interruption. Nevertheless, the comparator 94 detects that the voltage on its input connected to the lead 63 has dropped far below the voltage at the input connected to the terminal 26. The comparator 94 thereupon switches over such that it draws its power supply by way of the pilot lamp 59 and the terminal 26 and forms therefrom an "H" signal for activating the switch 91. A fault indication is thereby enabled despite the interruption of the lead 60.

The components indicated by solid lines have been included in the second embodiment of Fig. 3a, other components have been omitted, and the previous reference numerals are still used. An additional output of the amplifier circuit 79, which is connected in series with the regulator output stage 21, is connected to an input of an AND circuit 102 by way of a lead 101. The other input of the AND circuit 101 is connected to the output of the inverter 82 by way of a lead 103. The output of the AND circuit 102 is connected to an input of a switching delay stage 104 (tv2). The output of the switching relay stage 104 is connected to an input of the OR circuit 88 which is incorporated in the circuit element 89. Furthermore, a differential amplifier 125 (Sp. diff.) is provided. One input of the differential amplifier is connected to the terminal 39 (KL15) by way of a lead 127, the terminal 27 and a protective resistor 126 (R7). The other input of the differential amplifier 125 is connected to the terminal 28 which is connected to the terminal 129 (B + /GEN) by way of the series resistor 44 (R1). The output of the differential amplifier 125 is connected by way of a lead 128 to an input of the OR circuit 81 which is contained in the timing circuit 86 (tv1). Furthermore, a switching state 122 (US entr. = interruption of the sensing lead, de-excite) is provided whose input is connected to the output of the circuit element 72 (TK) by way of a lead 121, and whose output is connected to an input of an OR circuit 123. The output of the circuit element 76 is connected to the other input of the OR circuit 123. The output of the OR circuit 123 is connected to a further input 124 of the comparator 66. Finally, a voltage-dependent current-limiting circuit 111 is also provided. The current-limiting circuit 111 includes a measuring resistor 115 which is located in the lead 114 connected to the emitter of the indicator means output stage 91. The inputs of a measuring amplifier stage 116 are connected in parallel with the measuring resistor 115. The output of the measuring amplifier stage 117 is connected to a comparator 117.

Furthermore, the current-limiting circuit 111 includes an amplifier stage 113 whose input is connected to the terminal 36 (A) by way of a lead 112 and the resistor 35, and whose output is also connected to an input of the comparator 117. The output of the comparator 117 is connected by way of a lead 118 to a further input of the circuit element 89.

Fig. 4 is a variant of the second embodiment. A further switching delay stage 108 (dv3) has been added whose output is connected to a further input of the OR circuit 88 of the circuit element 89. The output of an AND circuit 107 is connected to the input of the switching delay stage 108. One of the two inputs of the AND circuit 107 is connected by way of inverter 106 to the lead 101 which leads from the amplifier circuit 79, and the other input of the AND circuit 107 is connected to the terminal 30 in the lead between the resistor 47 (R5) and the inverter 82.

As shown in Fig. 3b, the circuit element 72 includes a voltage divider comprising resistors 131, 132. One end of the voltage divider is connected to the sensing input terminal 129 by way of the terminal 28 and the resistor 44. The other end of the voltage divider 131, 132 is connected to earth. The tapping of the voltage divider 131, 132 is connected to the comparator 66 by way of a lead 143. The operating or output path of a transistor 133 is connected in parallel with the resistor 132 which is connected at one end to earth. The base of the transistor 133 is operatively connected to the tapping of a voltage divider 135, 136 by way of a decoupling transistor 144. The further voltage divider 135, 136 is a component part of a further circuit element

134, one end of the voltage divider 135, 136 being connected to the detection output terminal D + of the rectifier system by way of the terminal 29 and the resistor 45, and the other end of the said voltage divider being connected to earth. The block circuit diagram of this arrangement is shown in Fig. 3a, and details are shown in Fig. 3b.

Referring to Fig. 3a, a resistor 138 is connected between the detection output terminal D + and earth D −. Furthermore, the output stage transistor 21 of the voltage regulator includes a freewheeling diode 139 which is connected in parallel with the operating or output path of the transistor 21 between its collector and its emitter. The output stage transistor 91 of the indicator circuit also includes a diode 141 which, in the case, is connected in series in the collector lead.

The description of the function will be divided into the following sections:

1. Fig. 3—system intact
2. Fig. 3—output stage short-circuited
3. Fig. 4—system intact
4. Fig. 4—output stage transistor interrupted
5. Short-circuit of the indicator lamp
6. Interruption of the charging lead
7. Interruption of the sensing lead
8. Prevention of fault indication when the system is intact
9. Prevention of destruction upon switching off inductive loads

1. Fig. 3—system intact

If the regulating voltage, set on the comparator by the reference voltage divider 64, is exceeded, the blocking command of the comparator 66 is applied by way of the time-delay circuit 78 (tvr) to the amplifier circuit 79, serving as a driver stage, of the regulator output stage 21. The amplifier circuit 79, switches over. A signal, corresponding to the adjusting member signal (output stage potential) required for this operating state, is derived from the amplifier circuit 79 by way of the lead 101. Thus, the output stage normal signal for this state of operation is "H". This "H" is applied to one input of the AND circuit 102. Assuming that the indicator output stage 91 was conductive during the time domain before the switching-over of the comparator 66, an "L" signal is present at the terminal 30 (DF), even after the output stage normal signal exists until the indicator output stage transistor 91 can be rendered non-conductive (it is common knowledge that any transistor requires a certain time to assume its non-conductive state from its conductive state; in the present instance, the blocking-delay time of the indicator output stage transistor 91 is involved). As a result of this "L" signal at the circuit point 30 (DF), a second (H) signal is applied to the AND circuit 102 by way of the inverter 82 and the lead 103. The switching delay stage 104 (tv2) is thus activated. Thus, the switching delay time required of the switching delay stage 104 (tv2) can also be specified. It must be longer than the maximum possible blocking delay time of the indicator output stage transistor 91. In the present embodiment, the switching delay time of the switching delay stage 104 (tv2) has been established at 60 μsec.

2. Fig. 3—output stage short-circuited

The voltage of the vehicle electrical system exceeds the regulating voltage in the event of short-circuiting of the regulator output stage 21. This operation is dependent upon the state of charge of the battery 52, upon the instantaneous load to which the vehicle electrical system is subjected by the loads 54, and upon the rotational speed of the generator 10. The regulating voltage set on the comparator 78 by means of the reference voltage divider 64 is exceeded. Thus, the switching operation initiated is the same as that described above, in Section 1. An "H" signal appears as a normal signal at the input of the AND circuit 102 by way of the lead 101. Since the output stage 91 of the regulator is short-circuited, the potential on the terminal 30 (DF) does not follow the standard signal 101 after the maximum possible blocking delay time. The indicator output stage 91 is activated after the switching delay time of the switching delay stage 104 (tv2) has been exceeded. The pilot lamp 59 lights up.

3. Fig. 4—system intact

The embodiment of Fig. 4 shows a possibility of expanding the embodiment of Fig. 3. This embodiment is also compatible and can be used in mass-produced voltage regulators for monitoring the function of the output stage of the regulator.

If, as a result of loading of the vehicle supply system by the loads 54, the regulating voltage set by the comparator 66 is passed in a negative direction, the operation described above in Section 1 takes place in the reverse direction. The normal signal on the lead 101 switches over to "L". Thus, an "H" signal is applied to the AND circuit 107 by way of the inverter 106. After the maximum switching-on relay time of the transistor 91 of the indicator output stage has elapsed, the adjusting member signal on the terminal 24 (DF potential) follows the prescribed signal. The second input of the AND circuit 107 also carries an "H" signal until the potential on the terminal 24 (DF) changes. The delay stage 108 (tv3) is activated. The switching delay time required for the delay circuit 108 (tv3) must be longer than the maximum possible switching-on delay time of the indicator output stage 91.

4. Fig. 4—output stage transistor interrupted

In the event of interruption of the regulator

output stage 21, the voltage of the vehicle electrical system drops below the regulating voltage set on the comparator 26 by means of the reference voltage divider 64. As described in Section 3, the normal signal on the lead 101 changes to an "L" signal. An "H" signal thus appears at one input of the AND circuit 107 by way of the inverter 106. Since the output stage transistor 21 is non-conductive, the adjusting member signal on the terminal 24 (DF) cannot follow the normal signal on the lead 101. The indicator output stage 91 is activated after the expiry of the switching delay time 108 (tv3), and the lamp 59 lights up.

The function of the other components will be described hereinafter.

5. Short-circuit of the pilot lamp

The potential at the terminal 36 (H) is measured by the circuit 111 for voltage-dependent current limitation by way of the lead 112 and results in a reference value. The current-limiting circuit 111 then steps up the emitter current of the transistor 91 of the indicator output stage to an extent that the power for the cold current of the pilot lamp 59 is made available. On the other hand, the current-limiting circuit 111 prevents a rise of the emitter current beyond a predetermined value in the event of the pilot lamp 59 being short-circuited as a result of, for example, transposing the lamp terminals during assembly.

6. Interruption of the charging lead

The voltage regulator always controls the excitation output such that the output voltage on terminal 129 (B + /GEN) is complied with. The voltage regulator in the first instance cannot detect whether the charging lead, that is to say, the lead to the battery 52, is interrupted. If this lead to the battery 52 is then interrupted, the potential on the terminal 15, that is to say, at the terminal 39, drops slowly, since the battery 52 is not being charged. The pilot lamp 59 is switched on by way of the output stage 91 when the potential on the ignition switch 56 lies below the charging voltage by a predetermined amount (2 volts below 14.5 volts in the present embodiment).

7. Interruption of the sensing lead

If the line in the region of the terminal 129 (B + /GEN), that is to say, the sensing lead connected to the battery output of the generator 10, is interrupted, the actual battery voltage is not fed back to the voltage regulator. Consequently, the generator 10 would be fully excited and the charging voltage would continue to rise. When the circuit element 72 (TK) no longer supplies a signal as a result of an interruption, the comparator 66 is blocked by means of the switching state 122 (US entr. = interruption of the sensing lead, de-excite), such that the regulator output stage 21 is also blocked. Thus, forced de-excitation of the generator 10 is attained.

8. Prevention of a fault indication when the system is intact

The generator 10 is highly excited when a load 54 having a high power consumption is switched on. This is also the case when the battery 52 is fully charged. If the load 54 is switched off under these conditions, the load current continues to flow as a charging current into the battery 52. Consequently, the voltage on the terminals of the battery 52 increases to a considerable extent. The generator 10 is thereupon de-excited by the voltage regulator by way of the output stage transistor 21. The generator then remains entirely de-excited over a long period of time. The indicator circuit interprets this state as an interruption of excitation. When the potential on the detection terminal D +, and thus at the terminal 29, rises, the de-coupling transistor 144 slowly becomes conductive by way of the voltage divider 135, 136. However, the transistor 133 thus also assumes its conductive state. Thus, the parallel combination comprising the resistor 132 and the load resistance of the operating path of the transistor 133 becomes of smaller resistance. Consequently, the voltage divider 131, 132 becomes detuned. A smaller actual value is thus given to the comparator 66 by way of the lead 143. Consequently, a small amount of excitation is maintained by way of the output stage transistor 21 and prevents the detection output D + from dropping below a predetermined value. Thus, the switching threshold 67 is not passed in a negative direction. The components required for this measure are included in the component 142 of the readjustment circuit.

An ohmic resistor 138 having a value of approximately 1 kilohm is connected between the detection input D + and earth D −. The resistor 138 is connected in parallel with the high-resistance input of the readjustment circuit 142; the input resistor lies in the order of magnitude of 20 kilohms. The main current diodes 12 of the rectifier system have different leakage currents as a result of variations in the operating characteristics or as a result of different cooling conditions. When the generator 10 is not running, this should be indicated by the indicator circuit. However, with a high input resistance of the indicator circuit, high leakage currents could prevent the switching threshold 67 from being passed in a negative direction. The leakage currents are diverted by means of the resistor 138, so that a proper indication is given.

9. Prevention of destruction upon the switching-off inductive loads

When highly inductive loads are switched off by means of the operating switch 56, it must be possible for the inductive current to continue flowing. The current seeks its path from earth D − to the connection 39 (terminal 15) by way of the output stage transistor 21 and the freewheeling diode 42. However, the operating path of the output transistor 21 would be polarised in the reverse direction for this current. The high voltage which would then build up would destroy the output stage transistor 21. In order to prevent such destruction, the freewheeling diode 139 is provided and is connected across the operating path of the output stage transistor 21. Advantageously, this freewheeling diode is integrated on the chip of the output stage transistor 21.

However, if the connection between the terminal 39 and the terminal 15 is interrupted as a result of a defect, the inductive current seeks its path to the terminal 15 in some other way. The high voltage which is built up as a result of the switching-off of the inductive load also lies across the output stage transistor 91 of the indicator circuit. It would, in itself, be obvious also to provide a freewheeling diode at this location. However, this is prevented by the fact that the transistor 91 is a low-power transistor having correspondingly thin connection wires. The thin connection wires could not accept the switching-off current and would melt. For this reason, this current path has to be blocked. This is effected by the diode 141 which is connected in series in the collector lead of the output stage transistor 91 and which is reverse biassed for the induced current.

CLAIMS

1. A battery charging system, comprising an alternating current generator for feeding an electric battery and including an excitation system and a rectifier system, a semiconductor voltage regulator for maintaining the generator voltage constant and having a power switch connected in series with the excitation winding, and a charging indicator means which has a signal generator means for indicating the switching state of the power switch, a first threshold stage adapted to respond to a minimum value of the generator voltage, one signal input of the first threshold value stage being connected for this purpose to a fault detection terminal which is decoupled from the battery voltage and which is fed by detection diodes in the excitation system of the generator, and a second threshold value stage adapted to respond to a voltage which is produced by the generator and which exceeds the desired regulated value by a predetermined value one signal input of the second threshold stage being connected for this purpose to a sensing terminal influenced by the battery voltage, the output signals of which second threshold value stage are fed to a logic combination circuit which controls an indicator means.

2. A system as claimed in claim 1, in which the excitation winding of the generator is fed with voltage by a battery even during operation, and the fault detection terminal is fed with voltage solely by the detection diodes which are connected as a half-wave rectifier set.

3. A system as claimed in claim 1 or 2, in which the first threshold value stage is adapted to respond at a minimum value of the generator voltage which lies above the voltage value produced solely by the remanence of the excitation system at the maximum speed of the generator.

4. A system as claimed in any of claims 1 to 3, in which the output signals of the first threshold value stage and of the signal generator means, serving to detect the switching state of the power switch, are fed to a logic AND circuit which initiates an indication only when the power switch is conductive and the generator voltage is not higher than the threshold value of the first threshold value stage.

5. A system as claimed in any of claims 1 to 4, in which the output signals of the first threshold value stage and of a further threshold value stage, which is adapted to respond to a sensed generator voltage lying below the desired regulating value by a predetermined value, are fed to a logic AND circuit which initiates an indication only when the generator voltage is not higher than the threshold value of the first threshold value stage and the sensed voltage is lower than the threshold value of the further threshold value stage.

6. A system as claimed in claims 4 and 5, in which a time-delay circuit is connected to the outputs of the two said AND circuits, the time delay of which time-delay circuit corresponds to at least the time during which the voltage on the fault detection terminal rises from the minimum possible residual voltage to the maximum possible residual voltage at the minimum operating speed of the generator.

7. A system as claimed in claim 6, in which the said logic combination circuit which receives the output signals from the second threshold value stage is an AND circuit which is also connected to the signal generator means and whose output is also connected to the time delay circuit.

8. A system as claimed in any preceding claim, in which the fault detection terminal is connected to the signal input of an additional threshold value stage which is arranged to activate the indicator means and whose threshold value lies above that of said second threshold value stage.

9. A system as claimed in claim 8, in which the fault detection terminal is connected to the signal input of a second addi-

tional threshold value stage whose threshold value is higher than that of the first additional threshold value stage, and the output signals of these two additional threshold value stages are fed to AND circuit which suppresses indication when the second additional threshold value stage has responded.

10. A system as claimed in any preceding claim, in which the fault detection terminal is connected to the signal input of a safety stage which is arranged to block the power switch in the regulator when the voltage on the fault detection terminal rises to a predetermined value upon an interruption of the battery charging lead.

11. A system as claimed in claim 10, in which the safety stage acts upon a means for forming the threshold value of a comparator which is arranged to control the power switch, one signal input of which comparator is connected to a battery-voltage-dependent sensing point and the other signal input of which comparator is connected to a reference voltage divider.

12. A system as claimed in any preceding claim, in which a comparator is provided for activating the indicator means, one signal input of which comparator is connected to a constant voltage source, and the other signal input of which comparator is connected to another battery-voltage-dependent current path which does not include the sensing connection.

13. A system as claimed in claim 12, in which an ignition switch is connected to the battery and that terminal of the ignition switch which is remote from the battery is connected to the charging indicator means by way of a first lead and to the excitation winding of the generator by way of a second lead, one input of the comparator mentioned in claim 12 being connected to the first lead, and its second input being connected to the second lead.

14. A system as claimed in claim 12, in which one input of the comparator mentioned in claim 12 is connected to that portion of the charging circuit which leads from the generator to the battery, and its other signal input is connected to a battery-voltage-dependent current path, e.g. to the lead between an ignition switch, which is connected to the battery, and the excitation winding of the generator.

15. A battery charging system which includes a generator and a voltage regulator and in which, in operation, a normal signal is taken from a pre-amplifier circuit connected to the input of a voltage regulator output stage and is fed to an AND circuit; the output signal of signal generator means responsive to generator output voltage is fed to said AND circuit; the output signal of said AND circuit is fed to an OR circuit by way of a switching delay stage; the output signal of a timing circuit is also fed to said OR circuit; one input of the timing circuit is connected to the output of the signal generator means, by way of further components if necessary, and the output signal of the OR circuit is fed to indicator means, by way of an indicator output stage, if required.

16. A battery charging system as claimed in claim 15, in which the output signal of a differential amplifier is also fed to the timing circuit; one input of the differential amplifier is connected to a battery charging output of the generator, by way of a resistor if necessary; and the other input of the differential amplifier is connected to that terminal of an ignition switch which is remote from the battery, by way of a decoupling resistor, if necessary.

17. A battery charging system as claimed in claim 15 or 16, in which the indicator means is controlled by way of an indicator output stage, and in which a measuring resistor is located in the negative lead of the indicator output stage; the inputs of a measuring amplifier stage are connected to the ends of the measuring resistor; the input of another amplifier stage is connected to a terminal of the indicator means, by way of a decoupling resistor if necessary; the outputs of the amplifier stages are connected to a comparator; and the output of the comparator is connected to one input of a circuit element which includes the OR circuit.

18. A battery charging system as claimed in any of claims 15 to 17, which includes a circuit element having a temperature-dependent switching threshold, and a circuit part for emergency regulation, and in which the input of said circuit element is connected to the battery charging terminal of the generator; the output of said circuit element is connected to the input of a comparator and to the input of a switching stage serving to detect interruption of a battery voltage or generator voltage sensing lead; the input of said circuit part is connected, by way of further components if necessary, to one terminal of excitation diodes included in a rectifier system of the generator; the output of said switching stage and the output of said circuit part are connected to inputs of an OR circuit; and the output of the last-mentioned OR circuit is connected to an input of the last-mentioned comparator.

19. A battery charging system as claimed in any of claims 15 to 18, in which the output of a further switching delay stage is connected to a further input of the OR circuit mentioned in claim 15; the input of the latter switching delay stage is connected to the output of an AND circuit; one input of the last-mentioned AND circuit is connected to one terminal of the generator excitation winding; the other input of the last-mentioned AND circuit is connected by way of an inverter for the purpose of deriving the normal signal and to an output of said preamplifier circuit.

20. A battery charging system as claimed in claim 18, which includes a voltage regulator containing a comparator, in which the said circuit element includes a first voltage divider having resistors; the operating path of a transistor is connected in parallel with one of such resistors; the control path of the latter transistor is connected, possibly by way of further components included in a module, to the tapping of a second voltage divider comprising resistors and included in a further circuit element; and the input of the further circuit element is connected to a terminal which is connected to an output of a rectifier system of the generator.

21. A battery charging system as claimed in claim 18, in which an ohmic resistor is connected between said on terminal of the detection diodes and another terminal of the generator.

22. A battery charging system as claimed in any of claims 15 to 21, in which a freewheeling diode is connected in parallel with the operating path of the voltage regulator output stage.

23. A battery charging system as claimed in claim 22, in which the freewheeling diode is integrated on the chip of the voltage regulator output stage transistor.

24. A battery charging system as claimed in any of claims 15 to 23, in which a forward diode is connected in series with the operating path of the indicator output stage.

25. A battery charging system as claimed in claim 24, in which the forward diode is integrated on the chip of the voltage regulator output stage transistor.

26. A battery charging system constructed and adapted to operate substantially as herein described with reference to and as illustrated in the accompanying drawings.

Printed for Her Majesty's Stationery Office
by Burgess & Son (Abingdon) Ltd.—1982.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.